500kW/1075kWhBESSSolution

Ver.1.0

catalog

Record of Revision

Ver.	revised context	creator	Date
1	New version released		2022.10.21

1. Preface

This text appears to be a technical document discussing the development and requirements of an outdoor cabinet energy storage system. It is intended for use by personnel involved in the production, testing, inspection, and ordering of such systems. The document outlines the technical specifications for the components of the outdoor energy storage cabinet, as well as the production, testing, acceptance, packaging, storage, and transportation processes. It is specifically applicable to the initial prototype stage of development.

2. Abbreviation Definitions

No.	Abbr.	Definitions
1	BSM	Battery System Monitor
2	SOC	State of Charge
3	SOH	State of Health
4	FM200	（HFC-227ea），A clean gas chemical fire extinguishing agent
5	PCS	Power Conversion System
6	EMS	Energy Management System

3. Overview

The outdoor energy storage cabinet has characteristics such as simplified infrastructure construction costs, short construction cycles, highly modular, high environmental adaptability, and ease of transportation and installation. It can be used for various purposes including new energy peak shifting, peak shaving, load capacity expansion, and demand response. It is suitable for applications in markets, residential areas, schools, factories, farms, and other scenarios where new energy sources such as wind and solar energy are integrated.

4. Explanation of the Solution

4.1. System Overview

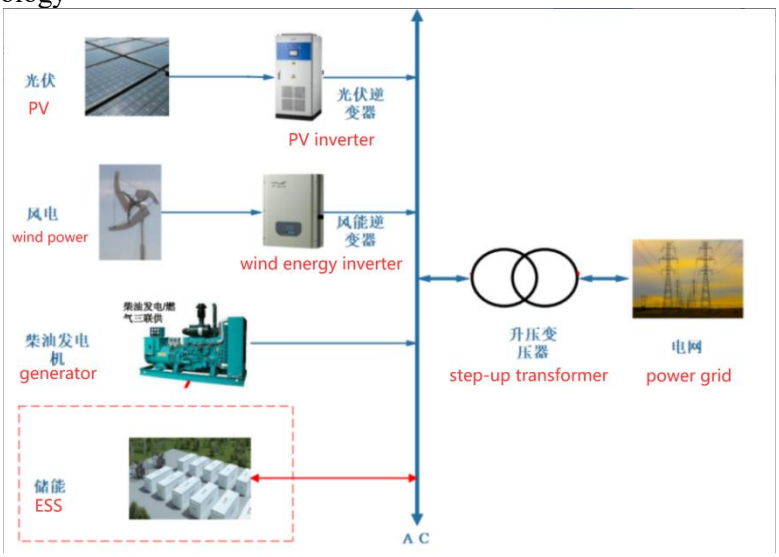
The outdoor energy storage cabinet system solution DC side nominal voltage 768V, rated power 500kW, system capacity 1075 kWh. The whole machine consists of 5 215kWh battery cabinets plus one 500kW PCS cabinet. The whole system contains several subsystems, namely energy storage system, battery management system, fire safety system, power distribution system (including power supply, convergence, lightning prevention, grounding, etc.) Lighting system, thermal management system, dynamic loop monitoring system, etc., the system has integrated energy storage converter, can be connected to the grid as a separate device.

The system has the following characteristics：

- Standardized design, modular assembly, flexible capacity configuration
- Intelligent integrated management, battery module plug and play, simple and reliable operation；
- High energy density and system conversion to ensure maximum available power；
- Software and hardware joint step protection mechanism, comprehensive insulation monitoring algorithm to ensure system security；
- Fast responsiveness, support for instantaneous full power input and output；
- Advanced thermal control design to ensure temperature consistency and longer service life；

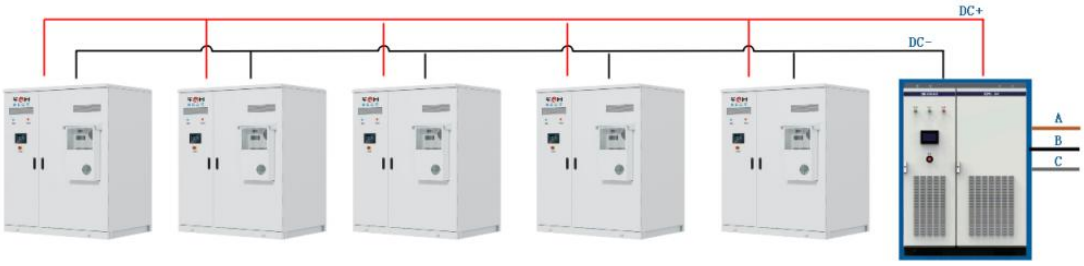
- Self-developed BMS battery management system with comprehensive battery management strategy and data analysis and support for local backup and storage of data;
- Advanced active equilibrium algorithm to increase system depth;
- Automatic calibration algorithm with intelligent correction SOC;
- Complete life cycle monitoring and recording of battery system with monitoring platform / Battery System Monitor (Optional);
- Compatible with communication interfaces such as Ethernet and RS485 and mainstream standard protocol protocols, customized solutions are also available
- Supports EMS scheduling and forms the Energy Internet;
- Support SCADA software monitoring and WEB direct access control;
- Supports system self-test and protection and provides remote upgrade services;
- Equipped with an intelligent cloud platform system to support cloud sharing, data analysis, report statistics, and analysis of operational status (optional)
- Integrated energy storage converter, integrated solution, reduce on-site installation process, plug and play, fast station construction, easy and efficient;

4.2. system topology



NO.1 Application of Storage System in New Energy

ESSs are in an indispensable position for new energy applications. Because of the instability of photostatic and wind power, The energy storage system makes the power output of new energy generation smooth. This allows for the transfer of energy over time, solving the disadvantage that traditional electricity can only be used instantly.。

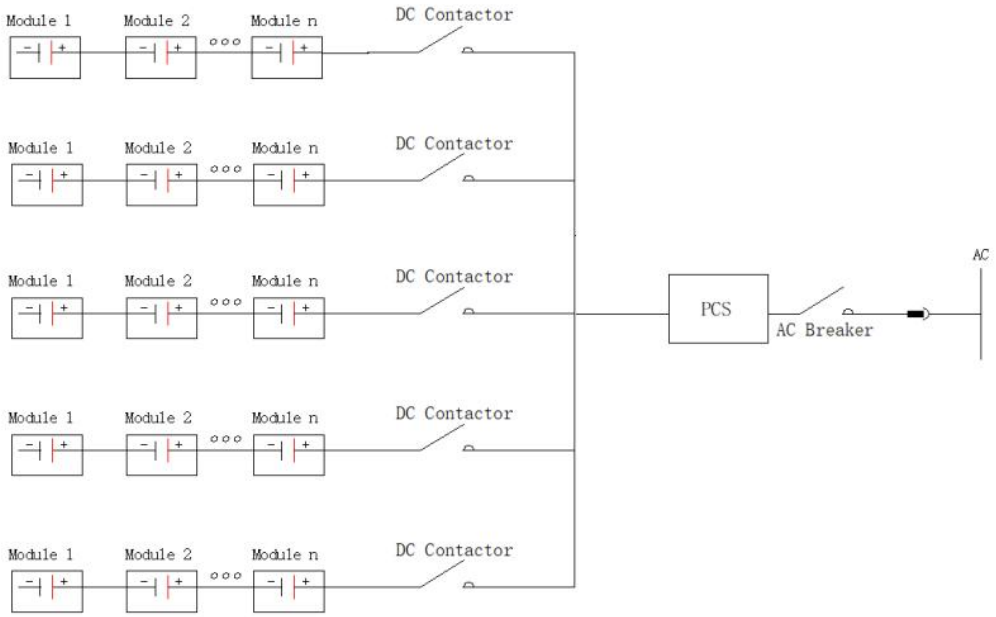


No.2 ESS Topology

Picture 2 shows the topology of the energy storage system consisting of 5 215kWh battery cabinets and one 500kW PCS cabinet; Each battery cabinet has a cluster of batteries built into it. Multiple cells (Cells) are formed in parallel into battery modules (Packs). Multiple battery modules form battery clusters (Racks) in series to boost the system's voltage. Each RACK uses an outdoor cabinet for integration, and five RACKs are connected in parallel to a PCS. The PCS is responsible for the AC/DC conversion of the system, allowing the system to connect to the grid.

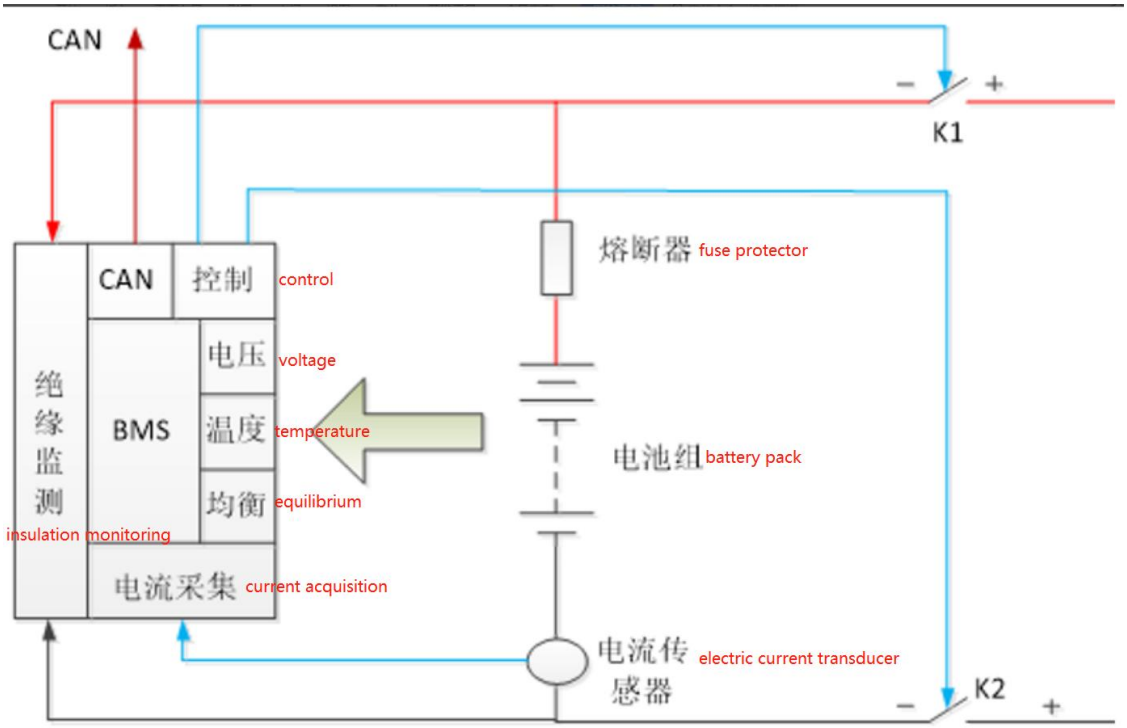
The outdoor cabinet system consists of 5 independent 215kWh energy storage battery cabinets and 1 PCS cabinet. The battery RACK is connected to the PCS from the DC concentration output of the high-voltage control box. After the PCS transition, the AC power is generated and connected into the grid via the AC port of the PCS. The system integrates a BMS state-of-the-art management system (battery array management system) , It can communications with each battery cluster management, and upper EMS and background cloud communication, as well as communication with PCS and the Supervision System.The operating status of the system, running data, and issue control instructions...etc are shown on a display.

Picture 3 shows the overall power loop principle of the outdoor energy storage cabinet system, with a total of 5 clusters of batteries centrally connected to the PCS via a DC port. Each 15 PACK is connected in series to the battery cluster control box, and each control box has a DC contactor inside that controls battery access to the PCS state.。



No.3 Power Loop Schematic Diagram

A single battery cabinet is a cluster of batteries. A single cabinet battery management system includes 1 master control module (With insulation monitoring function) and 15 slave control modules and cables.；

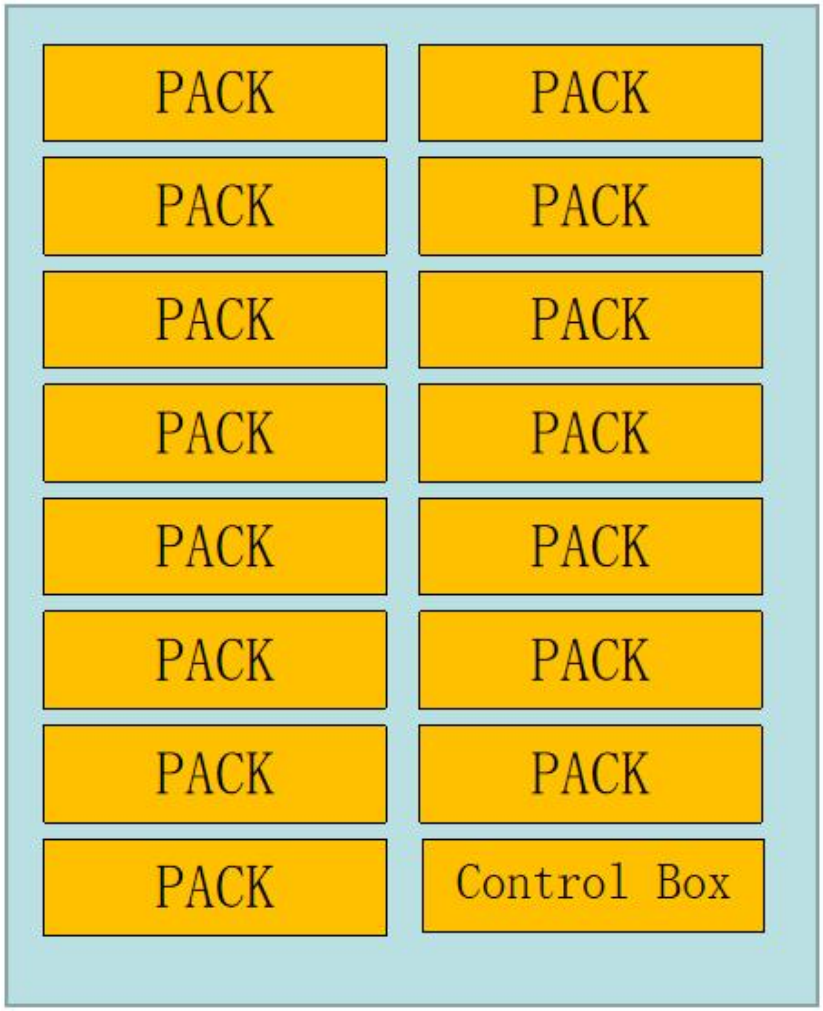


No.4 Electrical schematic diagram of a battery Rack

A contactor is installed between the battery system and the charging and discharging equipment to form a battery protection circuit to protect the battery from over-voltage, over-current, under-voltage, over-temperature, and other faults and repairs. In Figure 4, K1 is the charging contactor and K2 is the discharge contactor. Both K1 and K2 are controlled by the BMS.。

The operating principle: During the charging and discharge process, the battery packs output the voltage and power required by the system in series form, and then connect to the user's power conversion equipment into the required form of electricity for applications.When the battery packs are charging or outputting electric energy, the battery management system (BMS) monitors the voltage, current, temperature, insulation status, and other parameters of the battery packs, and estimates the power evaluation of the Energy storage system. It provides protection and early warning for various faults and shows alarm information on the display screen for user reference. At the same time, the charge and discharge circuit contactor can be closed or disconnected as needed to achieve control purposes.

4.3. Layout of battery cabinet



No.5 Layout diagram of outdoor energy storage cabinet (for reference only, subject to actual design)

The internal layout of the energy storage cabinet is shown in Figure 5. In order to prevent the heat generated by the equipment in the power distribution part from affecting the life of the battery, a heat insulation wall is used inside the cabinet to divide the cabinet into two independent spaces. The upper part is the electrical compartment, and the lower part is the battery compartment. The air conditioner is installed on the cabinet door。

The battery modules are placed inside the battery compartment, which is divided into two rows, Each row has 8 battery module positions, and the two rows have a total of 15 module positions and 1 control cabin. and there is a control box, central control box, and system power distribution control part placed on the top of the outdoor energy storage cabinet. This part does not participate in temperature control and relies solely on fans for ventilation. The top of the energy storage cabinet is equipped with a sun protection cover to prevent excessive internal temperature caused by direct sunlight. The bottom of the cabinet is an 85mm high base。

4.4. System Configuration Description

The basic information of this system is as follows：

1) A lithium iron phosphate cell with a single 280AH/3.2V;

2) Every single module is connected by the 1P15S connection way and managed by 1 Module - Battery Management System (M-BMS);

3) Every 15 battery modules are connected in series to form a battery cluster. Each cluster is managed by 1 Cluster - Battery Management System (C-BMS), which constitutes an energy storage battery cabinet;

4) Every five battery clusters form a battery energy storage system array unit, the unit is equipped with a 500kW Power Conversion System (PCS). The unit will be converted into alternating current （AC）and connected to the power grid.

5) The energy storage system is managed by an Array - Battery Management System (A-BMS);

6) Nominal voltage on the DC side of the system: 768V;

7) System nominal energy: 1075kWh;

8) System rated power: 500kW;

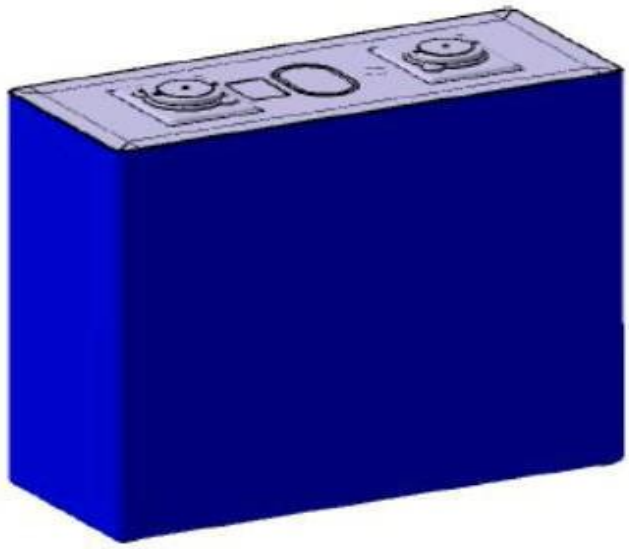
Table.2 Configuration info.

No.	**Sort**	**Item.**	**500kW/1075kWh BESS**	**Remark**
1	Config.	Rated Power	500kW	
2		Battery Type	LFP	
3		Rack Connection method (xPxS)	5P1S	
4		Battery Rated Energy (kWh)	1075	
5		Rated Capacity(Ah)	1400	
6	Charge and discharge parameters	Battery Rated Voltage (V)	768	
7		Maximum charging voltage (V)	856	
8		Discharge cutoff voltage (V)	672	
9		Rated discharge power (kW)	500	
10		Standard charging current (A)	600	
11		Standard discharge current (A)	600	
12		Maximum discharge current (A)	724	
13		Depth of Discharge	80%	
14	efficiency	System Efficiency	>85%	
18	Basic parameters	Ambient Temperature (℃)	-10~45℃	
19		Relative humidity	5%~95% No condensing	
20		Altitude (m)	<2000m	
21		Protection Class	IP54	
22		cooling mod	Internal air conditioning independent temperature control	Battery cabinet
23		Fire Fighting System	Sensor tube	Battery cabinet
24		communicate mod	Net	
25		Dimensions (L*W*H)/mm	about1200*1200*2150 mm	TBD

26		Weight(kg)	About 2000kg	TBD

5. About System module

5.1. Battery Cell

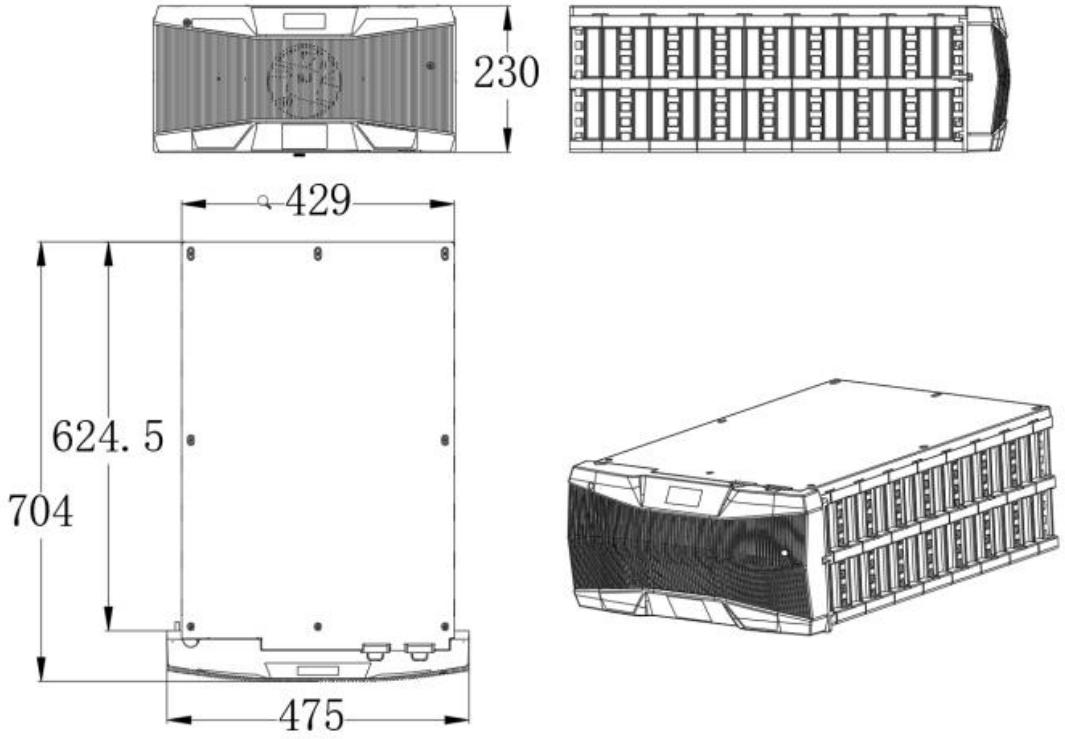


No.6 Lithium iron phosphate battery cell (LiFePO4)

No.	Sort	parameters	remark
1	Cell type	LiFePO4 / LFP	
2	Nominal capacity[Ah]	280	
3	Nominal voltage[V]	3.2	
4	voltage range [V]	2.5~3.65	Scope of use
5	Rating charging current [A]	0.5C	
6	Rated discharge current [A]	0.5C	
7	Maximum charging current [A]	0.5C	
8	Maximum discharge current [A]	1C	
9	Internal resistance	0.16±0.05mΩ	

	[mΩ]		
10	Operation temperature [℃]	-20~60	
11	Dimensions [mm]	71.65×173.9×207.2 (T×W×H)	
12	Life cycles	After 4000cycles, Capacity≥80% （25℃ 0.5C）	

5.2. Battery module



No.7 Battery module schematic diagram

No.	item	Specifications	Remark
1	combination mode	1P16S	
2	Nominal capacity [Ah]	280	
3	Nominal voltage [V]	51.2	

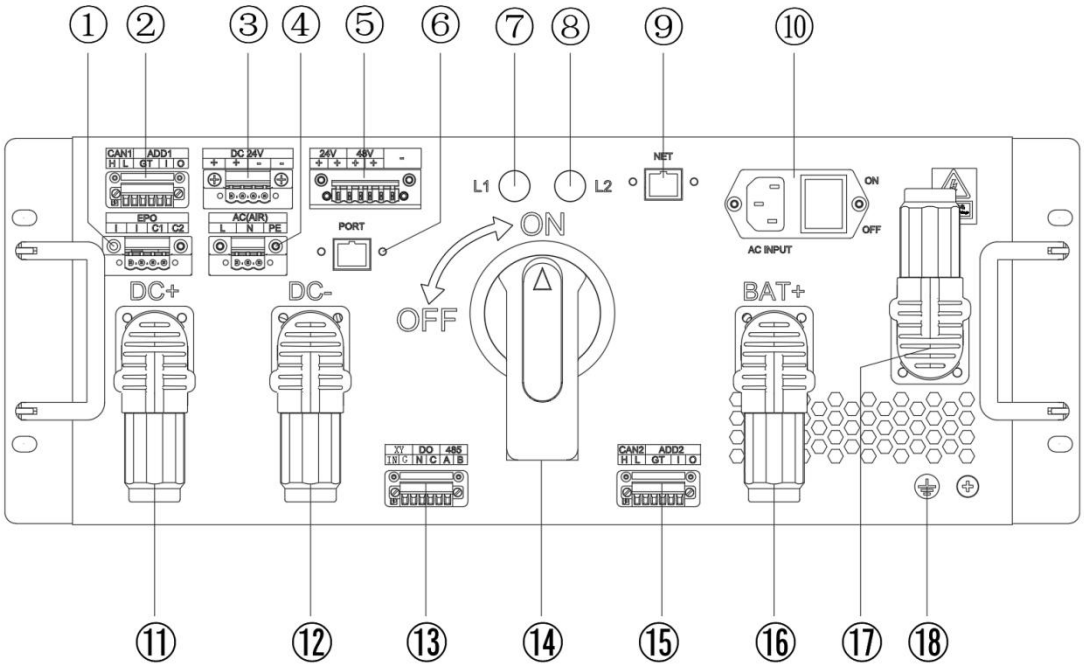
4	voltage range [V]	40~57.6	
5	Nominal energy [kWh]	14.336	
6	Maximum continuous charge and discharge current [A]	140A(0.5C)	
7	Maximum continuous charge and discharge voltage [A]	280A(1C）	≤10 min
8	Rated charging and discharge power [kW]	7.168	0.5CP
9	Maximum charging and discharge power [kW]	14.336	1CP
10	Working temperature [℃]	0~40	
11	Storage temperature	-20~45	
12	Altitude [m]	≤2000	
13	Operation humidity	5%~85% Rh	
14	Dimensions [mm]	475×704×230 mm（W×D×H）	
15	Weight [kg]	102	
16	Shell material	SMC，White	

5.3. Battery Cluster control box

The battery cluster control box integrates the control and management functions of the entire system.

The main part is the battery management system (BMS)

Its functions include: charge and discharge control and management function of battery cluster; insulation monitoring function; power calculation function during charging and discharging; temperature control function (integrated fan control function to control the temperature of the cabinet).

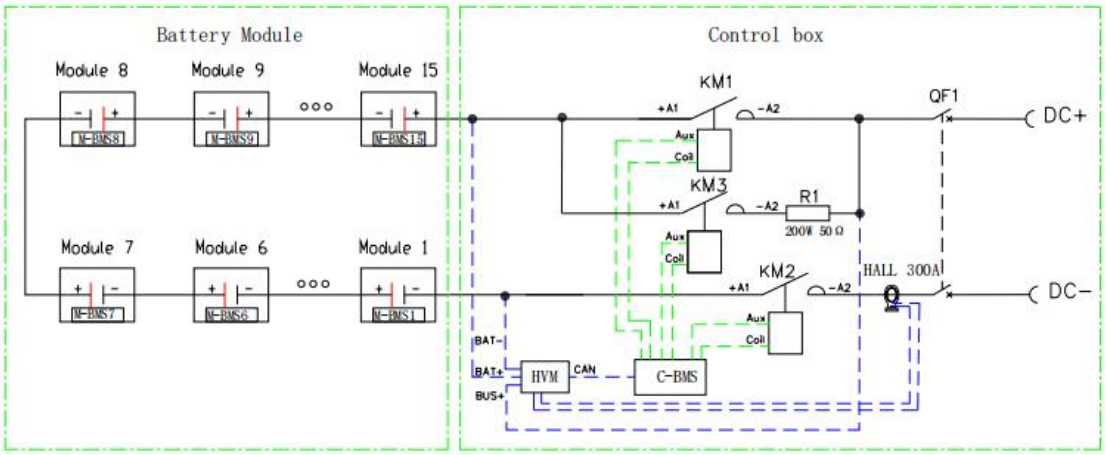


No.8 Control box operation interface

No.	Port	Function
①	Signal socket①	Used for emergency stop control and emergency stop signal input feedback
②	Signal socket②	BMS CAN1- Communication socket (communicate with module's BMS)
③	DC24V socket	For output DC24V, maximum output 3.5A
④	Air conditioner power socket	220V AC power output
⑤	DC fan power socket	For output DC48V, maximum output 4A
⑥	PORT socket	Used for the control of running lights, fault lights and input feedback of fire protection, flooding and access control signals
⑦	L1	Positive Pole Closing Light
⑧	L2	Negative Pole Closing Light
⑨	RJ45 port	BMS communication
⑩	3 Pins socket	220V AC input for switching power supply and air conditioner power input
⑪	DC+	Connect the positive pole of the external device
⑫	DC-	Connect the negative pole of the external device
⑬	Signal socket⑬	Used for lightning protection signal input, dry contact control signal output and 485 communication
⑭	DC molded case circuit breaker	Manual circuit breaker
⑮	Signal socket⑮	BMS CAN2 Communication interface (external)
⑯	BAT+	Connect the positive pole of the battery cluster
⑰	BAT-	Connect the negative pole of the battery

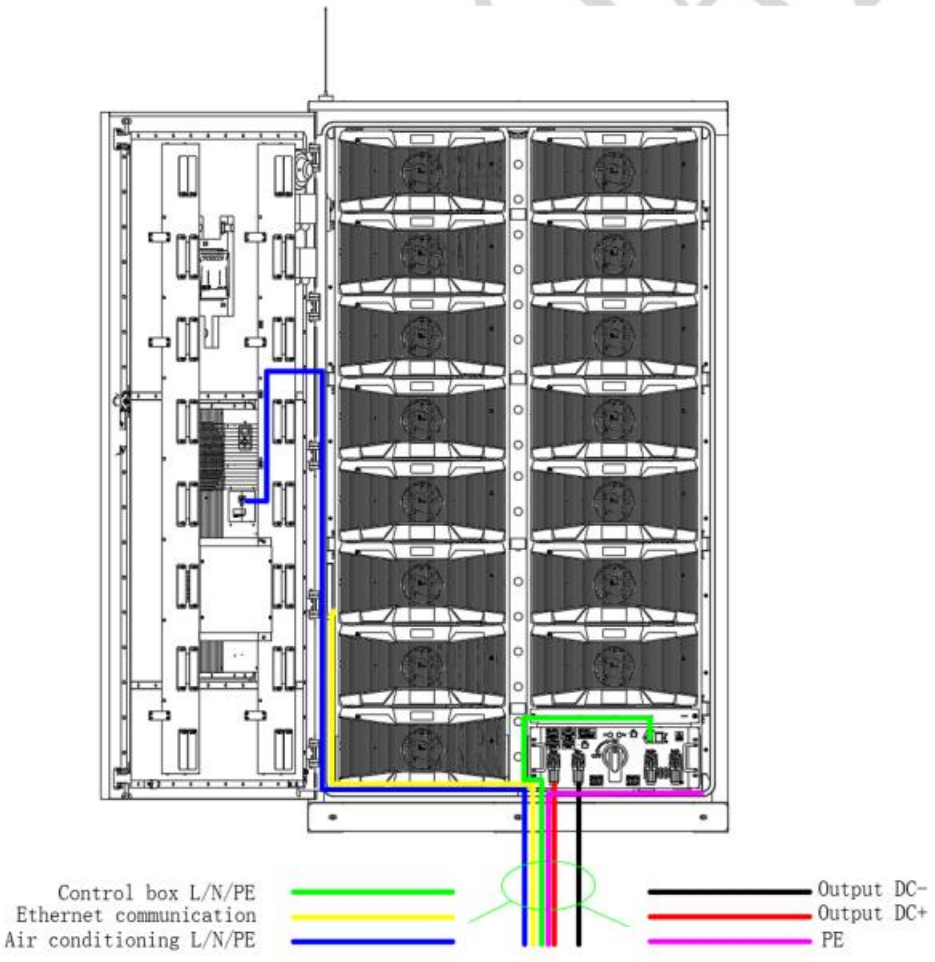
		cluster
⑱	PE	battery cluster control box ground point / earthed point

5.4. Battery Cluster



No.9 Battery cabinet/rack schematic diagram

The battery rack is divided into two columns, with a total of 8 layers, for placing battery modules. The battery rack is equipped with 15 battery modules and 1 battery cluster control box. The bottom outlet method is adopted, and the specific battery cabinet arrangement is as shown in the figure below.



No.10 Battery cabinet/rack schematic diagram

Sort	performance	Specification
Battery Rack	Product number	EL518
	Nominal energy	215kWh
	Rate voltage	768V
	Maximum Charging Voltage	864V
	Maximum discharge Voltage	648V
	Rate charging current	140A
	Rate discharge current	140A
	Maximum continuous charging power	107.5KW(0.5P)
	Maximum continuous discharge power	107.5KW(0.5P)
	Operation temperature	-20～45℃
	Storage temperature	-30～60℃
	communicate mod	net
	Relative humidity	5%~95% No condensing
	Altitude(m)	<2000 m
	Cooling mod	Forced air cooling for power electronics
	Protection Class	IP54
	Weight	About 1.9T
	Dimensions	L 1200±3mm
		W 1000±3mm

		H 2085±3mm

5.5. PCS

The system comes with one 500kW independent Power Conversion System (PCS), and the PCS is placed in an independent cabinet. It uses a 3L+PE outgoing line method, and its monitor shows the System operation data monitoring、strategy control、 history data record 、status record, etc. The PCS supports a variety of communication protocols to communicate with various devices.

The characteristics are as follows：

- It can be paralleled with more batteries；
- Advanced drooping control method, the average score of the voltage source parallel power can reach 99%；
- Supports battery packs with higher voltage and higher power；
- The structure is simple, reliable, and stable, with high -efficiency, and low-network harmonic content；
- Designed for smart grids, receiving grid scheduling, independent adjustment of meritorious, non -contribution；
- Use dual power redundant power supply to improve system reliability
- Support multiple communication methods and communication protocols；
- Front connection type wiring and repair, and modular design saves more space；
- Comprehensive failure and operating log records；

NO.	sort	Specification	Remark
1	DC	DC600V～DC900V	
2	Rated power	500kW	
3	Grid type	3L	
4	Rated voltage	AC400V	
5	Frequency	50Hz	
6	Frequency Range	Rated frequency±3Hz	
7	power factor	1	
8	THDi	≤3%	
9	Operation Temperature	-35℃～55℃（Derating over 45℃）	
10	Storage temperature	-40℃～70℃（without battery）	
11	Relative humidity	0 % RH ～ 95 % RH ， No condensing	
12	Operation Altitud	45℃，4000m（ Derating）	
13	Nois	68dB	
14	Communication Port	RS485、CAN、LAN	
15	Communication Protocol	CAN、ModBus TCP	
16	Installation method	Cabinet	
17	Maximum efficiency	98.7%	
18	EMC	Class A	
19	Isolation	non-isolated	
20	Protection Class	IP20	Outer cover

21	cooling	Forced air cooling	
22	Dimensions(W*H*D)	1100*2160*800mm	
23	Weight	600kg	

About the Battery Management System (BMS)

6.1 Overview

As a monitoring equipment for battery energy storage system devices, BMS mainly has the following functions:

BMS is divided into module management unit (M-BMS), battery cluster management unit (C-BMS), battery array management unit (A-BMS), DC monitoring unit (HVM) and display screens. The control unit has single -section voltage monitoring, temperature monitoring, balanced management, and CAN communication functions; the main control unit has battery pack current monitoring, insulation monitoring, total voltage monitoring, and CAN communication function; CAN communication, SOC estimation and SOC calibration function.

The main technical indicators of BMS

No.	Sort	Specification
1	Cell temperature detection range	1-4.5V
2	Cell voltage measurement accuracy	±5mV @25℃
3	Battery temperature detection range	-40℃～120℃
4	Battery temperature measurement accuracy	±1℃
5	current measurement accuracy	FSR±1%
6	SOC estimation	≤5%
7	Equilibrium Function	Two-way Automatic Equilibrium Function
8	fault alarms	Over-voltage and under-voltage, over-temperature, over-current, etc. fault alarms
9	Communication	Net/RS485
10	Insulation resistance calculation function	Yes
11	Data storage	SSD

BMS mainly includes hardware, software and supporting debugging parts:

Hardware includes: A-BMS, C-BMS, M-BMS, HVM, display.

Software includes: single -board software and touch screen software (remarks: software is not provided separately)

In the architecture of the battery management system:

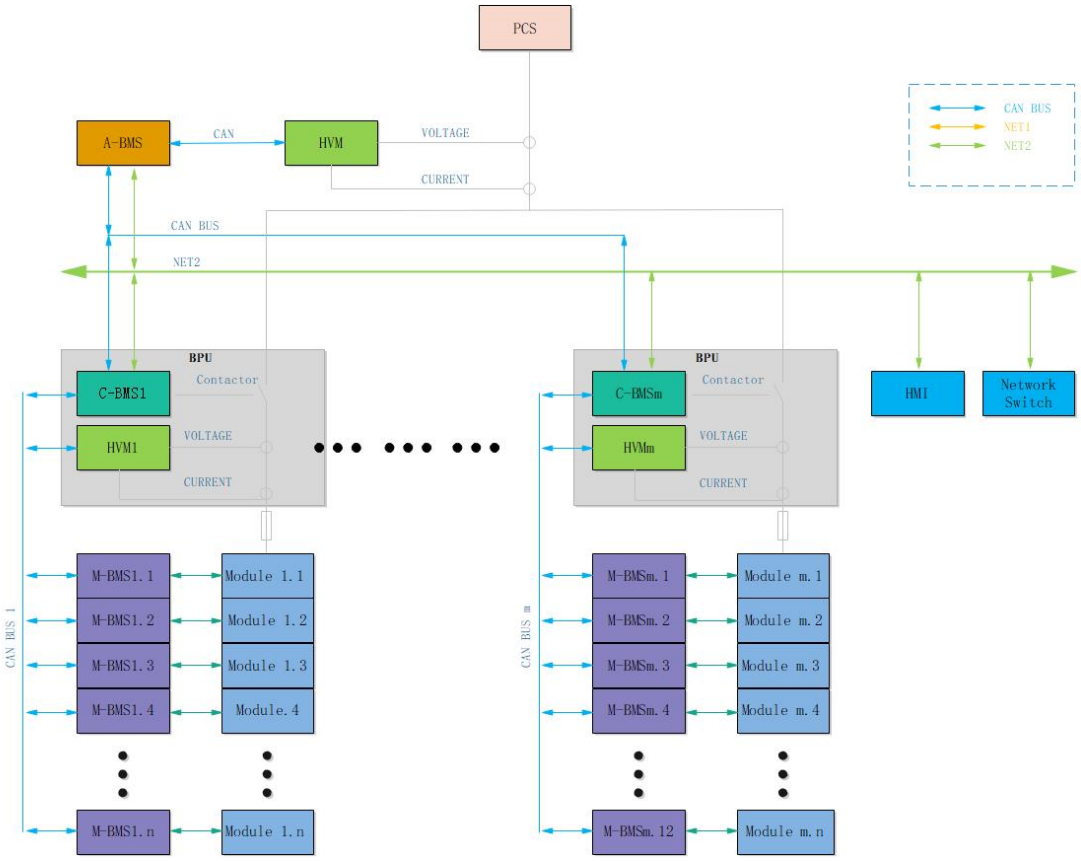
1) The core control module C-BMS of BMS mainly assumes analysis, calculation, data processing, and communication functions.

2) As the BMS data collection module, M-BMS mainly distributed in the battery box, undertakes the voltage, temperature, and other functions of each single battery. Each module's hardware and software are the same, only the address is different.

3) The display screen is used to display each battery-related data in the battery management system, which is convenient for monitoring the status of the entire battery system.

6.2 BMS communication topology

BMS has a 3-layer architecture. The bottom layer is the battery module management unit （M-BMS）, which is placed in the battery module and is responsible for collecting the cell voltage and temperature of the battery module and controlling the balance of the cells. The M-BMS of multiple battery modules reports individual cell data to the upper management unit （C-BMS） via the CAN bus. At the same time, the DC monitoring unit will monitor the charge and discharge current of the battery cluster, the total voltage of the battery cluster and the insulation condition, and report the corresponding data to the C-BMS via the CAN bus. C-BMS obtains the cell data of multiple battery modules and the total current and voltage data of the cabinet. By analyzing these data, it can achieve the purpose of measuring the charge and discharge of the cabinet and the battery state of charge (SOC). At the same time, C-BMS of multiple battery clusters can report cluster data to A-BMS through Ethernet. A-BMS can realize data exchange with the backend through Ethernet. A-BMS communicates with external charging and discharging equipment through RS485 or Ethernet to control and protect the charging and discharging of the cabinet battery.



No.12 BMS communication topology

7. Subsystem introduction

7.1 About the temperature control system

This system comes with 5 battery cabinets and 1 PCS cabinet. The PCS cabinet uses a forced-air cooling method. The battery cabinet has high requirements for the operating temperature of the operating temperature, so it uses a closed design and industrial air conditioner to dissipate heat.。

Air conditioning power calculation

The thermal management plan is designed according to the actual geographical environment of use of the energy storage system, and matching air conditioners are selected according to the heating and cooling capacities. If used in high-altitude areas, the cooling capacity or heating capacity is calculated according to the loss factor. If it is used in an environment with a small temperature difference, the air conditioner power can be appropriately reduced.

Referring to the existing air conditioning parameters on the market, 2kW or 3kW door-mounted industrial air conditioners can already meet the heating and cooling capacity requirements. (When choosing a door-mounted air conditioner, installation holes must be left on the cabinet door in advance.)

Cabinet air duct design

Each outdoor cabinet comes with an industrial air conditioner to keep the operating environment temperature of the system within the optimal operating temperature range of the battery cells. Since the heat exchange efficiency between the battery Cluster and the outside air is greatly reduced after the battery modules are formed into a battery cluster, the battery cluster is designed with cabinet air ducts to quickly take away the heat. So the battery cluster is designed with cabinet air ducts to quickly take away the internal heat so that the battery cells can operate in the optimal temperature range.

7.2 About fire protection system

If there is a fire or even an explosion inside the battery cabinet, the automatic fire protection system will respond quickly and activate the fire extinguishing system to release FM200 （HFC-227ea）to extinguish the fire.

The battery cabinet uses an HFC-227ea fire suppression tube device. The fire extinguishing system is mainly composed of three parts: a container (suppression tube) for storing fire extinguishing agents, a pressure gauge, and a feedback device connected to the container.

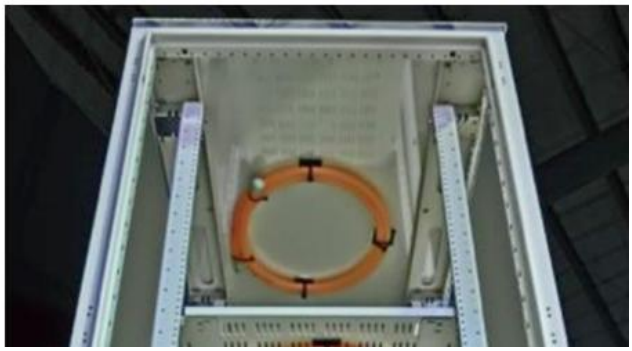
The fire suppression tube has both automatic fire detection and fire extinguishing agent storage functions. Suppressor tubes are installed near or above where fire sources are most likely to appear. In the event of a fire, the suppression tube explodes autonomously, and then the fire extinguishing agent is transported to the blast hole through the suppression tube pipeline for spraying, then extinguishing the fire.

The fire suppression tube is installed on the top of the battery module inside the battery cabinet, as shown in Figure No. 14。

The advantages of suppressor tube fire protection systems：

- The unique fire extinguishing effect can effectively put out fires in an embryonic stage。
- Automatically starts in case of fire, no power required, no manual operation required 。
- Suitable for unattended equipment and places that require key protection
- Fast detection and response times reduce losses caused by fire spread
- The suppression tube is equivalent to a linear detector, which can detect fire and release fire-extinguishing medium
- Simple design, easy installation, takes up very little space, which can reduce installation and maintenance costs
- Non-full coverage type, which will not harm people in the protected area when releasing the fire extinguishing medium
- No mistaken alarms or releases due to the influence of oil, dust, etc.
- There are no electrical components, and the device will not be affected by vibration or impact.
- The tube is a flexible tube that can be arranged in various small spaces.

➢ Maintenance-free, no additional operation and maintenance costs, and long service life；



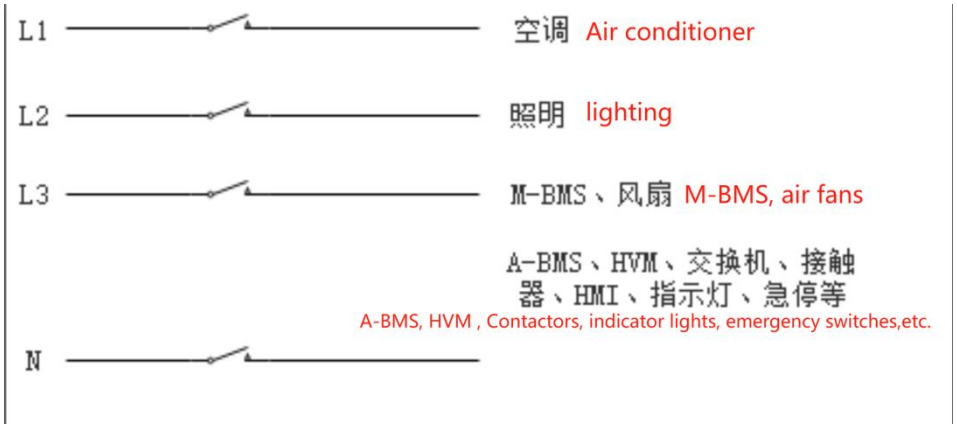
No.14

7.3 About Lighting system

It controls the lighting inside the outdoor energy storage cabinet and provides a safe lighting environment for monitoring inside the cabinet. The lighting is controlled by a travel switch to achieve the effect of turning on the lights when opening the door and extinguishing the lights when closing the door.

7.4 About Power Distribution System

1） High voltage power distribution section,
Including power connection from battery cabinet to PCS, main control switch, etc.
2）Low voltage power distribution section,
Including power supply circuits, signal circuits, etc. of each subsystem



2） About lightning protection

Install anti-surge protection modules at the protection nodes on the line to prevent damage to the system from lightning strikes.

According to customer needs and actual use environment, choose a lightning arrester with auxiliary alarm contacts. Once a lightning strike occurs, an external alarm signal can be sent through the real-time monitoring platform, and the system will automatically switch to the corresponding monitoring interface and issue corresponding processing prompts.

The lightning protection circuit must have a reliable grounding design so that the large current generated during a lightning strike can be conducted to the earth. The PE port of the lightning arrester can be connected to the ground bar provided by the cabinet to the user through a PE wire with a wire diameter that meets the requirements.

3） Cabling system

The wiring path design facilitates installation and maintenance and minimizes power lines connection. Power lines and control communication lines should be routed separately to reduce crosstalk between lines；

7.5 About earthing system

Outdoor energy storage cabinets provide Earthing bars. The Earthing bar forms a reliable equipotential connection with the non-functional conductors of the entire energy storage system (the metal shell of the battery cabinet that is not charged under normal circumstances, etc.). At the same time, each energy storage cabinet provides users with at least 1 earthing point that meets the strictest electrical standards。

8. Note

(1) When the system is in use, it should be kept away from fire, heat, and water sources. If the battery leaks or emits a peculiar smell, it should be stopped immediately and relevant personnel should be notified in time for processing;

(2) If the system is not used for a long time, the battery should be fully charged and fully discharged once a month. The recommended charge and discharge rate is 0.3C, and detailed records should be kept;

(3) When the battery is stored for a long time, the battery state of charge should be adjusted to 30%.